this with a protecting layer of porcelain paste and after drying to bend the whole into spiral form by means of a blowpipe. The glower, which is composed of a mixture of zirconium oxide with the yttria-erbia oxides, is, of course, while cold a non-conductor of electricity. Heated, however, by the heater it begins to conduct, rendering itself hotter by its own current energy, getting hotter and hotter until it reaches its normal brilliant state of incandescence. The glower current flowing through the coils of the cutout magnetises the same, causing it to pull in its armature and break the heater current at C.

An unfortunate feature of the Nernst glower is that at the necessary state of incandescence the voltage across it decreases with increase of current. If one wished to express this mathematically, one would say its $\delta v/\delta a$ (v = volts, a = amperes) is negative. A conductor possessing this property placed across supply mains of constant voltage is, however, in an unstable state of equilibrium and will not burn properly. The function of the series resistance R is to correct this. This consists of a very fine iron wire placed inside a glass bulb containing hydrogen gas at low pressure. The thickness of the iron wire is so chosen that at the normal current it is just at its critical stage, *i.e.* at that point, just under the red heat, where its $\delta v/\delta a$ is highly positive; the instability of the glower by itself is thus compensated and the whole glower circuit across the mains is rendered stable.

The smaller lamp, used for all candle-powers below fifty, consists of essentially similar parts to the larger model already described.

As to the economy of the Nernst lamp, the following table shows the result of a test carried out by the Physikalische Technische Reichsanstalt, of Berlin:—

Mean of five lamps. Pressure 220 volts.

Time (hours).	Candle-power.	Watts per candle.
0	35·1	1·65
50	32·4	1·77
100	32·3	1·77
200	30·1	1·85
300	27·5	1·93
400	26·5	1·97
Mean during 400 hours	30·1	1·83

The average life was 380 hours. The heaters were not damaged.

Unfortunately, no information is given as to the source of supply on which these tests were made. Experience already acquired shows that this is of great importance as determining the life of the glowers. Of course, on the basis of 1·8 watts per candle, for a life of 400 hours, the Nernst lamp works out at a saving of about 40 per cent., first cost and renewals included, over ordinary incandescent lamps.

We believe that the lamp is finding, or will find, considerable commercial application, and we anticipate for it a very useful and prosperous future.

C. C. GARRARD.

NATURAL PROPORTIONS IN ARCHITECTURE.[1]

IT is well known that formal decoration must be based upon exact geometrical construction. The history of art and architecture shows that the most beautiful buildings and formal ornamental *motifs* are those depending upon definite and regular principles. The symmetry of architecture consists of the rhythmical repetition of certain parts of a design in relation to a plan or scheme as a whole, or uniformity as regards the answering of one part to another. The symmetrical forms of Nature have the same interdependence of detail. If a flower is examined which possesses a definite and unmistakable symmetrical adjustment of part to whole, it will furnish a case in point. If even a glimpse could be obtained of the manner in which Nature made the adjustment of her detail, it seemed not unreasonable to expect that the principles involved would be of assistance to design. Even a casual examination showed that much of the harmony of relationship of parts in regular objects could be expressed graphically by geometrical lines. It was found by experiment that this expression was very simple. In most cases, a few circles described concentrically would entirely satisfy zones of symmetry involved in some forms. In addition to the formal plans disclosed in plants, with their leaves, flowers and fruit, the author investigated the beautiful curves of the wings and bodies of butterflies, beetles, moths and bees. He found that in all such examples, these curves were best satisfied by the tangent arcs of circles which had their radii determined by a simple ratio. This ratio almost invariably was a double or binary one, the unit being obtained from the length of the subject's body. With such a unit as a radius, a circle would be described; the diameter of it would be taken as a radius for another, the radius of this for still another, and so on. This progression would be continued until enough arcs had been secured to satisfy all the curves involved. The tangent arcs of circles so related would satisfy these curves, so that it would be impossible for the eye to detect any difference between the approximated and the actual form.

The circles used to satisfy curves of natural objects in this manner may be termed binary circles. They are really circles having radii which form a geometrical progression with a ratio of two. By describing these binary circles concentrically, many proportions involved in the plans of certain forms were accounted for. There were other proportions, however, which these circles did not explain, but the three simple figures which compose the regular polyhedra are involved in the construction

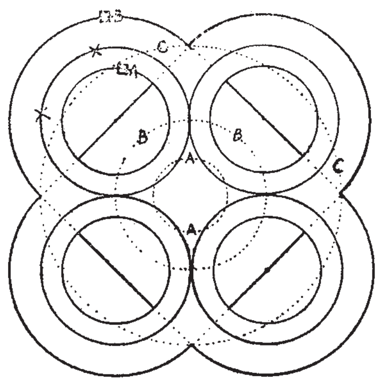
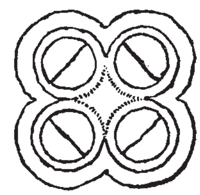


FIG. 1.

A A Primary Circle 1.
B B ,, ,, 2.
C C ,, ,, 3.
□ A Circle 1 derived from □ in A.
□ B Circle 2 ,, ,, □ in A.
× = □ ○ in Circle A.
The symmetry expressed formally.



Cross section of young fruit and contained seeds of the verbena.

to satisfy them. There are but five possible regular polyhedra, and the three simple figures which compose their faces are the equilateral triangle, the square and the regular pentagon. Once having obtained the primary circles, these simple regular figures may be inscribed in any one of a binary series and a side of each used as a radius to describe others concentrically.

With this simple geometrical formula, it is possible to account for every possible combination of symmetry and proportion. Snow crystals and mineral crystals furnished, so to speak, the converse aspect of the curved forms of organic nature. The straight lines used in the graphic expression of the form of a crystal of any system may be shown to be connected with circles such as have been described. The precision with which this formula analyses the symmetrical shapes of Nature is very remarkable.

If the master architects and decorative artists of the past were guided by Nature, we ought to find an agreement between the proportions of curve and straight line which they employed in their plans and the plans of regular natural objects. This is exactly what a general analysis of architecture and formal art has disclosed. As the designer has used good or bad proportions in his architectural and decorative compositions, there may be found, by this method of analysis and comparison, harmony with the proportions which Nature employs.

The fact that the simple figures of the polyhedra are involved in all symmetrical forms of Nature has naturally suggested that their proportional properties be investigated. If these figures are considered as representing elements of symmetry and the

[1] Abstract of a paper read before the Hellenic Society on November 4 by Mr. Jay Hambidge.

peculiar manner in which they lend themselves to subdivision or multiple expansion is examined, it will be seen that they are inseparably connected with circles which have their radii related in the manner described. Study of these figures will enable one to tell, by merely looking at a proportioned object, the order of its symmetry or character of its plan. For instance, in a cross-section of the young fruit and contained seeds of the verbena, certain circles are involved in relationship to a square. Without making any measurements from the fruit, the plan can be accurately formulated (Fig. 1).

This construction is simple, but it involves principles which are far-reaching. The ground plan of the Parthenon is an instance of architectural construction where the detail is co-ordinated in much the same manner.

The basal projection of the crystal of topaz (Fig. 2) involves all the proportions which occur in regular forms. There are the primary circles the radii of which form the geometrical progression with the binary ratio, and the secondary circles as derived from the sides of the equilateral triangle, the square and the regular pentagon. This example also includes the odd proportion derived from the perpendicular of an equilateral triangle. This

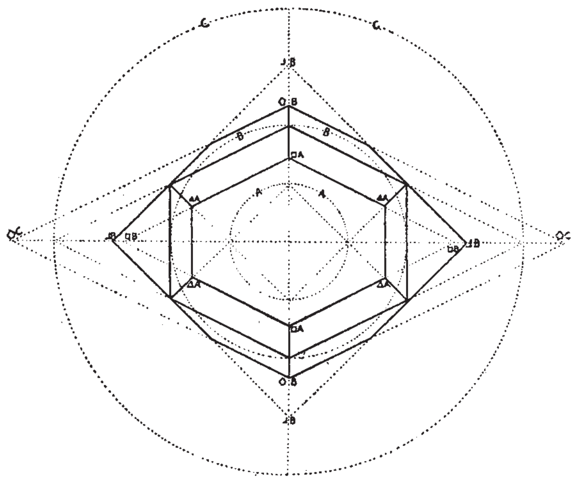


FIG. 2.—Crystal of topaz—basal projection.

A A Primary circle 1.
B B ,, ,, 2.
C C ,, ,, 3.
Distance of point □ A from centre determined by □ in A.
,, ,, △ A ,, ,, ,, △ in A.
,, ,, B ,, ,, ,, in B.
,, ,, □ B ,, ,, ,, □ in B.
,, ,, ⊥ B ,, ,, ,, ⊥ in B.
,, ,, ⬠ C ,, ,, ,, ⬠ in C.

This crystal base contains the entire scheme of proportion and symmetry as found in the Parthenon.

is the only proportion found in symmetrical natural form which seems to be connected with an arithmetical progression.

The Greek and Gothic styles of architecture furnish the most satisfactory results in a comparison of their curves and proportions with the curves and proportions of natural symmetrical forms. In the finest example of the former, the Parthenon, the agreement is so extraordinary that all its proportions and curves may be obtained with no other instrument than a string and a couple of sticks. A surface of levelled earth would furnish a place to make the simple constructions. The beautiful curves found in this building, which so simulate those of conic sections as to deceive the expert mathematician, can be accounted for by this method. In fact, there is no curve in Greek formal art which may not be simply, rapidly and accurately drawn with a compass, and when so drawn, the circles used will be found to possess a definite relationship one to the other. This method would seem to furnish a simple explanation as to how the Greek architects used these curves so long before their supposed discovery. The agreement between the plans of the regular forms of Nature and the plans of the best buildings would seem to suggest that the great architects possessed a formulated or intuitive knowledge of simple principles of proportion which are unknown to us.

[1] ⊥ is the symbol for the perpendicular of the equilateral triangle.

EARTHQUAKES AND EARTH PHYSICS.

PROF. J. MILNE, F.R.S., read a paper on "World-shaking Earthquakes" before the Royal Geographical Society on November 11. In the course of his paper, he remarked that earthquakes may be divided into two groups—first, those which disturbed continental areas, or even the world as a whole, which he called macroseismic, and, secondly, local earthquakes disturbing a few miles' radius, or not more than 100 or 200 miles, which he called microseismic. Evidence of the existence of large earthquakes was sometimes afforded, even though they could not be felt; for example, in 1755, the motion of the water in lakes and ponds observed in England, Scandinavia and North America was attributed to the earthquake at Lisbon. Another form of evidence was sometimes discovered by astronomers, as in May, 1877, M. Nyrén observed disturbances in the level of the axis of the transit at Pulkova, which were held to be due to an earthquake about an hour and a quarter earlier at Iquique. The first instrumental record obtained by the writer of an earthquake which could not be felt was in March, 1884. This and others were referred to as "slow earthquakes." A long series of observations justified him in saying, in 1883, that every large earthquake might be recorded at any point on the land surface of the globe. Thus a new field was open to seismologists, and recording stations were now to be found in many countries, the most complete organisation working in connection with a committee of the British Association. A large earthquake seemed to propagate a series of waves in all directions through and in all directions over the world's surface. Describing in detail the character of this motion, he said that the large waves of earthquakes seemed to pass beneath a country like ours with the character of an ocean swell. The character of these waves was still in process of investigation, and there were reasons for and against any conclusions which might be reached. It would appear that the effective rigidity of the world was about twice that of steel, and it was easy to measure the difference in time between the arrival of preliminary tremors and of large waves—the former reaching a place 80° from their origin in about fifteen minutes, whilst large waves took about fifty minutes. From these differences in times of arrival of different waves, distances of origins could be obtained, and from the distance ascertained from several distant stations the origin might be easily located. Another method of ascertaining origin was the difference of the times of arrival at different stations of large waves, and by these methods the origin of the world-shaking earthquakes for 1899, 1900 and 1901 had been determined. Prof. Milne established a relationship between the distribution of the origins of large earthquakes and the pronounced irregularities of the surface of the earth by a number of illustrations taken from the Alaskan region, which had yielded large seismograms to the Cape of Good Hope, which was antipodean to Alaska, the Cordillerean region, the Antilles, the Andes, Japan, and other parts of the world. He also gave an historic account, dating from 1692, of the mass displacements which had been caused by great earthquakes. As examples, in 1855, in New Zealand, 4600 square miles were raised 1 foot to 9 feet; and in 1897, in Assam, according to Mr. R. D. Oldham, 10,000 square miles of country were displaced possibly 16 feet along a thrust plane.

The connection between large earthquakes and volcanic activity was considered; and instances were given of the seismic convulsions which apparently resulted in reliefs of volcanic strain. So recently as the early part of last summer, the symptoms of volcanic and seismic activities in the Western Hemisphere culminated in the terrible explosions in Martinique and St. Vincent. Prof. Milne also gave the result of inquiries into the relationship between world-shaking earthquakes and unusual movements of magnetic needles. At certain stations, the unfelt waves of large earthquakes disturb magnetic needles, but this is not the case at all stations. This difference in behaviour is not explicable on the assumption that the movements are due to tilting of the instruments, but it is possible that they may be due to magnetic influences. The stations at which movements are observed, Prof. Milne suggests, may be nearer to the magma in which the large waves are propagated than the other stations where movements are not observed. Inasmuch as this magma is not only magnetic, but is also dense at the former stations, the observed value for g would exceed that at the remaining stations, *caeteris paribus*. In support of this view, figures were adduced. References were made to small changes in latitude. When